TABLE 317-1 THE THREE COMPARTMENTS OF THE MEDIASTINUM

	Anterior Compartment	Middle Compartment	Posterior Compartment
Anatomical boundaries	Manubrium and sternum anteriorly, pericardium, aorta, and brachiocephalic vessels posteriorly	Anterior mediastinum anteriorly, posterior mediastinum posteriorly	Pericardium and trachea anteriorly; vertebral column posteriorly
Contents	Thymus gland, anterior mediastinal lymph nodes, internal mammary arteries and veins	Pericardium, heart, ascending and transverse arch of aorta, superior and inferior vena cavae, brachiocephalic arteries and veins, phrenic nerves, trachea, and main bronchi and their contiguous lymph nodes, pulmonary arteries, and veins	Descending thoracic aorta, esophagus, thoracic duct, azygos and hemiazygos veins, sympathetic chains, and the posterior group of mediastinal lymph nodes
Common abnormalities	Thymoma, lymphomas, teratomatous neoplasms, thyroid masses, parathyroid masses, mesenchymal tumors, giant lymph node hyperplasia, hernia through foramen of Morgagni	Metastatic lymph node enlargement, granulomatous lymph node enlargement, pleuropericardial cysts, bronchogenic cysts, masses of vascular origin	Neurogenic tumors, meningocele, meningomyelocele, gastroenteric cysts, esophageal diverticula, hernia through foramen of Bochdalek, extramedullary hematopoiesis

mediastinitis. Most cases are due to histoplasmosis or tuberculosis, but sarcoidosis, silicosis, and other fungal diseases are at times causative. Patients with granulomatous mediastinitis are usually asymptomatic. Those with fibrosing mediastinitis usually have signs of compression of a mediastinal structure such as the superior vena cava or large airways, phrenic or recurrent laryngeal nerve paralysis, or obstruction of the pulmonary artery or proximal pulmonary veins. Other than antituberculous therapy for tuberculous mediastinitis, no medical or surgical therapy has been demonstrated to be effective for mediastinal fibrosis.

PNEUMOMEDIASTINUM

In this condition, there is gas in the interstices of the mediastinum. The three main causes are (1) alveolar rupture with dissection of air into the mediastinum; (2) perforation or rupture of the esophagus, trachea, or main bronchi; and (3) dissection of air from the neck or the abdomen into the mediastinum. Typically, there is severe substernal chest pain with or without radiation into the neck and arms. The physical examination usually reveals subcutaneous emphysema in the suprasternal notch and *Hamman's sign*, which is a crunching or clicking noise synchronous with the heartbeat and is best heard in the left lateral decubitus position. The diagnosis is confirmed with the chest radiograph. Usually no treatment is required, but the mediastinal air will be absorbed faster if the patient inspires high concentrations of oxygen. If mediastinal structures are compressed, the compression can be relieved with needle aspiration.

318 Disorders of Ventilation

John F. McConville, Babak Mokhlesi, Julian Solway

DEFINITION AND PHYSIOLOGY

In health the arterial level of carbon dioxide (Pa_{CO_2}) is maintained between 37 and 43 mmHg at sea level. All disorders of ventilation result in abnormal measurements of Pa_{CO_2}. This chapter reviews chronic ventilatory disorders.

The continuous production of C_{O_2} by cellular metabolism necessitates its efficient elimination by the respiratory system. The relationship between C_{O_2} production and Pa_{CO_2} is described by the equation: $Pa_{CO_2} = (k)\ (\dot{V}_{CO_2})/\dot{V}A$, where $\dot{V}_{CO_2}$ represents the carbon dioxide production, k is a constant, and $\dot{V}A$ is fresh gas alveolar ventilation (Chap. 306e). $\dot{V}A$ can be calculated as minute ventilation × (1 – Vd/Vt), where the dead space fraction Vd/Vt represents the portion of a tidal breath that remains within the conducting airways at the conclusion of inspiration and so does not contribute to alveolar ventilation. As such, all disturbances of Pa_{CO_2} must reflect altered C_{O_2} production, minute ventilation, or dead space fraction.

Diseases that alter $\dot{V}_{CO_2}$ are often acute (e.g., sepsis, burns, or pyrexia), and their contribution to ventilatory abnormalities and/or respiratory failure is reviewed elsewhere. Chronic ventilatory disorders typically involve inappropriate levels of minute ventilation or increased dead space fraction. Characterization of these disorders requires a review of the normal respiratory cycle.

The spontaneous cycle of inspiration and expiration is automatically generated in the brainstem. Two groups of neurons located within the medulla are particularly important: the dorsal respiratory group (DRG) and the ventral respiratory column (VRC). These neurons have widespread projections including the descending projections into the contralateral spinal cord where they perform many functions. They initiate activity in the phrenic nerve/diaphragm, project to the upper airway muscle groups and spinal respiratory neurons, and innervate the intercostal and abdominal muscles that participate in normal respiration. The DRG acts as the initial integration site for many of the afferent nerves relaying information about Pa_{O_2}, Pa_{CO_2}, pH, and blood pressure from the carotid and aortic chemoreceptors and baroreceptors to the central nervous system (CNS). In addition, the vagus nerve relays information from stretch receptors and juxtapulmonary-capillary receptors in the lung parenchyma and chest wall to the DRG. The respiratory rhythm is generated within the VRC as well as the more rostrally located parafacial respiratory group (pFRG), which is particularly important for the generation of active expiration. One particularly important area within the VRC is the so-called pre-Bötzinger complex. This area is responsible for the generation of various forms of inspiratory activity, and lesioning of the pre-Bötzinger complex leads to the complete cessation of breathing. The neural output of these medullary respiratory networks can be voluntarily suppressed or augmented by input from higher brain centers and the autonomic nervous system. During normal sleep, there is an attenuated response to hypercapnia and hypoxemia, resulting in mild nocturnal hypoventilation that corrects upon awakening.

Once neural input has been delivered to the respiratory pump muscles, normal gas exchange requires an adequate amount of respiratory muscle strength to overcome the elastic and resistive loads of the respiratory system (Fig. 318-1*A*) (Chap. 306e). In health, the strength of the respiratory muscles readily accomplishes this, and normal respiration continues indefinitely. Reduction in respiratory drive or neuromuscular competence or substantial increase in respiratory load can diminish minute ventilation, resulting in hypercapnia (Fig. 318-1*B*). Alternatively, if normal respiratory muscle strength is coupled with excessive respiratory drive, then alveolar hyperventilation ensues and leads to hypocapnia (Fig. 318-1*C*).

HYPOVENTILATION

CLINICAL FEATURES

Diseases that reduce minute ventilation or increase dead space fall into four major categories: parenchymal lung and chest wall disease, sleep-disordered breathing, neuromuscular disease, and respiratory drive disorders (Fig. 318-1*B*). The clinical manifestations of hypoventilation